Forest Ecology and Management 256 (2008) 191–193

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Preface

Impacts of forest ecosystem management on greenhouse gas budgets

For more than 15 years, forest management activities have been a point of contention in the context of sustainable development and the UN Framework Convention on Climate Change (UNFCCC). The UNFCCC and its Kyoto Protocol (KP) requests that countries reduce greenhouse gas (GHG) emissions and/or increase GHG removals by using agriculture, forestry and other land use activities (AFOLU) or other sequestration techniques. Under Article 3.4 of the KP, countries may choose to account for forest management activities to help them meet their obligations to curb GHG emissions.

In August 2005, scientists, policy-makers and other stakeholders came together in a workshop in Savonlinna, Finland, to discuss the impact of forest management activities on GHG budgets. The aims of the workshop were: (i) to review the scientific state-of-knowledge regarding the effects of forest management on the GHG budgets; (ii) to scrutinize the availability of suitable inventory methods needed to document management effects on the GHG budgets; and (iii) to discuss policy relevant questions linked with the UNFCCC reporting practices.

1. Understanding management-induced changes in GHG budgets

There is a rich body of scientific literature regarding the effects of forest management on growth, productivity, and hence carbon sequestration. However, it is very difficult to derive general conclusions because the variation of site quality and the history of site development/disturbance events often obscure the differences in management-induced changes in carbon stocks.

The scale of any carbon assessment is crucial. Conclusions based on observations from spatially or temporally limited studies can be misleading. For example, in the comparison of harvest regimes, the average storage within a management unit is the only criteria that can be compared. Interactions between management history and climatic effects on the temporal trends in carbon storage need to be recognized, and it is generally advisable to look at longer time scales, not just at one point in time.

When carbon stocks are compared between unmanaged and managed forest stands, unmanaged stands typically show higher stocks. However, it is important to recognize that these results are biased due to the exclusion of disturbance impacts. The main disturbance factors in North America are fire and insect outbreaks; storms have been more important in Europe. With increasing stand age, fewer and fewer stands remain undisturbed, and mature carbon-rich stands are rather exceptional in most forest zones. To avoid this potential bias, one solution would be to increase the scale of investigation and to analyse average carbon storage across larger regions and longer time scales.

Another important consideration during the GHG budget analyses is the definition of system boundaries. Assessments of forest management impacts should also include carbon storage in products and carbon substitution effects (e.g. avoided fossil fuel emissions through using forest biofuels). The optimal solution for climate protection can only be found by including the whole carbon life-cycle; drawing the system boundary at the forest border may produce very misleading results.

2. Measuring and modelling management-induced changes in carbon storage

There are different sources of data for measuring carbon stocks: forest inventories, inventories of other variables (soils, vegetation, etc.), and plot/site level experimental data from intensive ecosystem research. However, the integration of different data sources/databases, and the harmonization across countries and approaches present an array of challenges.

Data are available at two different scales. Plot/site level data are key for the understanding of the underlying processes of carbon sequestration/emission, and the detailed detection of management-induced changes. Regional/national assessments from inventories and stratification of many individual plots provide the broader picture and integrate different processes (e.g. age effects, disturbances). Temporal scales complicate the interplay between small spatial scales (plot/site) and large spatial scales (inventory), but modelling may bridge these scales and provide additional insights. For improved assessment of management impacts, forest inventories should include more parameters/measurements. Inventories of non-tree components (e.g. soils and understory vegetation) and dead wood need to be coupled with tree inventories, because assessing GHG budgets requires an accounting of the whole ecosystem response.

In order to account for human-induced changes, a clear cause and effect relationship between management practices and carbon stocks in different compartments of the ecosystem is required. Unfortunately, establishing these cause and effect relationships is not straight-forward as the effects of management strategies vary in different settings. Consequently, management related information is needed from forest inventories to enable stratification according to management classes. However, in most current inventories, only very basic management information is included, and besides species distributions, little information is available at larger scales.

While traditional national forest inventories provide an overall assessment of forest carbon stocks, additional analysis is needed to attribute stock changes to specific management activities and stand dynamics. Detecting management-induced changes in national forest ecosystem carbon balances thus requires a hybrid approach utilizing inventories and models. This could include: (i) forest inventory data (expanded with soils, vegetation, and dead wood information); (ii) an inventory of management practices and changes thereof; and (iii) model analysis of stand dynamics and carbon stock changes. Consequently, estimating forest carbon stock changes and impacts of management activities will require not only further forest inventory developments, but also further refinements of stand dynamics models and linkages to the national forest inventories.

3. The science-policy interface

The third focus of the workshop was to facilitate interaction between scientists and policy-makers related to the UNFCCC, KP, and specifically the questions concerning forest management activities under KP Article 3.4. Many scientists lack an understanding of terms and definitions relevant to the climate change policy process, particularly with respect to requirements for fulfilling country commitments under UNFCCC and the KP. During the workshop, policy experts who had directly participated in the policy process shared experiences and lessons learned from the first commitment period of the Kyoto Protocol. Weaknesses of the current rules were identified and possibilities for developing more successful rules for the future were discussed.

Data on AFOLU activities should be available on a country-specific basis to provide long-term trends in carbon stocks and their variability, and the potential amount of enhancement for relevant activities (e.g. management of forests and grasslands). This information is needed to assess the magnitude of possible GHG emissions and removals by forest management activities in future climate protection efforts. A future AFOLU "system" should be less complex, allow for more flexibility (i.e., accounting for national circumstances) and include incentives to reduce deforestation. It would be helpful to develop targets for AFOLU to facilitate meeting the overall targets of the UNFCCC. Issues related to AFOLU will probably remain politically and technically complicated, and fresh constructive suggestions for future rules are needed.

No matter what the future framework for addressing forest management activities in international climate agreements will be, decision makers will be interested in which forest management changes (including project offsets) will be most relevant for their particular country. In this context, a number of information needs arise: the potential area, average carbon benefits per unit of land and realistic associated costs. Moreover, the risk of reversing GHG gains, and possible negative environmental direct and indirect effects of changing environmental conditions on the benefits of the activities as well as co-benefits and other side-effects (positive and negative) all need to be evaluated. Finally, monitoring systems for detection and estimation of these effects will be needed.

The papers in this special feature address some of these issues in more detail. The first paper is the outcome of the working group discussions that aimed to summarize the scientific state-of-knowledge on the effects of forest management on the GHG budget. Nabuurs et al. reviewed and categorized potential forest management options for maximizing forest carbon pools and carbon sequestration in Europe. They identified regional differences in potentials for increased carbon sequestration and risks for losses of carbon from forest ecosystems.

Thinning of stands has been a common silvicultural practice in many European countries. Nilsen and Strand investigated the effects of thinning intensity on carbon and nitrogen fluxes in the soil, tree layer and ground vegetation in spruce stands in Norway. One key finding of the study was the importance of site variability which overlaid the carbon stock changes in the soil due to management differences.

In central Europe, Norway spruce has been planted widely on sites naturally dominated by broadleaved species. Some of these planted sites are particularly prone to natural disturbances, including storm damage and pest/disease damage. Seidl et al. used the PICUS model to study the effects of bark beetle disturbance on timber production and carbon sequestration in a Norway spruce forest under conditions of climate change and over a time period of 100 years.

Woodall et al. used the down and dead woody materials (DDW) survey of the United States (part of the USDA Forest Service's Forest Inventory and Analysis program) as a case study to examine the challenges of inventorying DDW at a national scale, reviewed how dead wood carbon pools are currently estimated in the National Greenhouse Gas Inventory (NGHGI), and suggested opportunities for improving such inventories.

Köhl et al. provided an example of using forest inventory data to estimate forest management impacts on the carbon balance. Their study assessed the effect of different assumptions on the decay of dead wood resulting from harvests and natural mortality. They found that for a given set of inventory data the reported 10-year change of carbon stock varied between 3.1 tonnes C ha^{-1} $yr^{-1}$and 34.4 tonnes C ha^{-1} yr^{-1}.

There are a number of ways to estimate the carbon sequestration in forests. The inventory-based method (in combination with a bookkeeping model) is often considered as a reliable method. This method can be used to validate results from inverse modelling. Nabuurs et al. compared the uncertainties associated with estimates for carbon sequestration derived using the CO2FIX model for a temperate forest and a tropical forest. They found that the uncertainties of the carbon stock estimates were larger in tropical forests than in the temperate forests. However, even in the case of the temperate forest where there was good access to data, the uncertainties were such that it would be difficult to detect carbon stock changes caused by changes in forest management.

Overall, the selected papers from the workshop provide valuable examples of the current state of national-scale forest GHG budget analysis and its intersection with requirements from international policies.

Acknowledgements

We wish to acknowledge the EU funding for CarboEurope GHG (grant EVK2-CT2001-00307) and thank all participants for active and stimulating discussions. The list of participants can be found in the workshop report at http://www.efi.int/attachments/events/2005/savonlinna_ghgworkshop_report.pdf.

M. Lindner*
Tim Green
European Forest Institute, Torikatu 34,
80100 Joensuu, Finland

C.W. Woodall
C.H. Perry
USDA Forest Service,
Northern Research Station,
1992 Folwell Avenue, St. Paul, MN, 55108, USA

G.-J. Nabuurs
ALTERRA, P.O. Box 47, NL 6700 AA Wageningen, The Netherlands

M.J. Sanz
Fundación CEAM, Parque Tecnológico, c/Charles H. Darwin 14, 46980 Paterna (Valencia), Spain

*Corresponding author
E-mail address: marcus.lindner@efi.int (M. Lindner)

0378-1127/$ – see front matter
© 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.foreco.2008.04.005